THE AMERICAN UNIVERSITY IN CAIRO

School of Sciences and Engineering

CSCE 2303– Computer Organization and Assembly Language Programming

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Project II: Memory Hierarchy Simulator

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Description of the implementation

1. Struct Cache

   We used a struct to hold the attributes of the Cache such as the total cache size S, the cache line size L, and the number of cycles needed to access the cache. There are also some other attributes like:

   1. Hit and miss (They used to keep track of the number of the hit and miss times)
   2. Count (It is used to keep track of the number of accesses)
   3. isHit (It is a boolean value to check whether it is hit or miss)
   4. vector<int> sequence (A vector to store the sequences after reading them from the access sequence text file imputed by the user)
   5. vector<long>index (It is used to store the indices)
   6. vector<bool> valid (It is used to store if it is valid or not)
   7. vector <pair<int, int> >cacheContent; (It is used to hold the tag and the content of the cache)

   There are also other features but they are made for the bonus case which is supporting separate caches for instructions and data such as,

   1. vector<char> seqCheck (It is used to know if it's Instanous or Data)
   2. vector<pair<int, int>> cacheInst; (It is used to store the tag, instantaneous content)
   3. vector<pair<int, int>> cacheData; (It is used to store the tag and data content)
   4. vector<bool> validInst (It is used to store the valid of instantaneous)
   5. vector<bool> validData (It is used to store the valid of data)
   6. int instS (To store the total cache size S of the instantaneous)
   7. int dataS; (To store the total cache size S of the data)

2. Map Memory

   We used a map for the memory. The first value is the address and the second is the content.

Important Functions:

1. Read

   It is a function that is used to read any of the text files only by sending the name of the text file entered by the user like “memory.txt”. Also, it gets the integer which accordingly read a specific file. For example, 0 is to read the memory file, 1 is to read the Address Sequence file, and 2 is to read the labeled address sequence.

2. Print_Output

   It is used to print the output whether it is for the labeled case or the original case and it does so according to a boolean value passed to it.

3. Split Sequence:

   It iterates over the sequence vector to split the sequence and get the index, tag, and validity. It calls the print function output each iteration.

Bonus Features

We did one bonus which is supporting separate caches for instructions and data. In this case, each of the memory addresses in the provided sequence must be labeled as either an instruction or data access.

Design Decisions and Assumptions

We assumed that the user will enter the name of the text files in the directory of the project. So, the user will enter only the name such as “memory.txt”, not the directory of the file.

Bugs or Issues

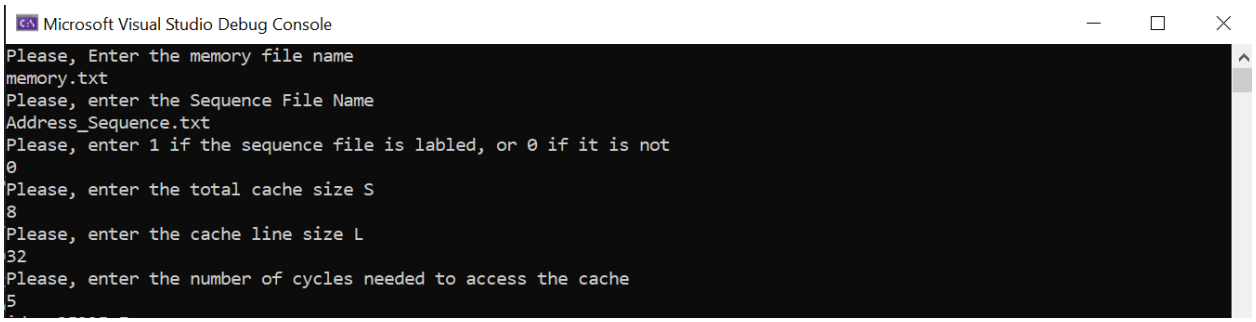
There are no known bugs or issues with our code.

User Guide

The user will be doing the following steps in the same order:

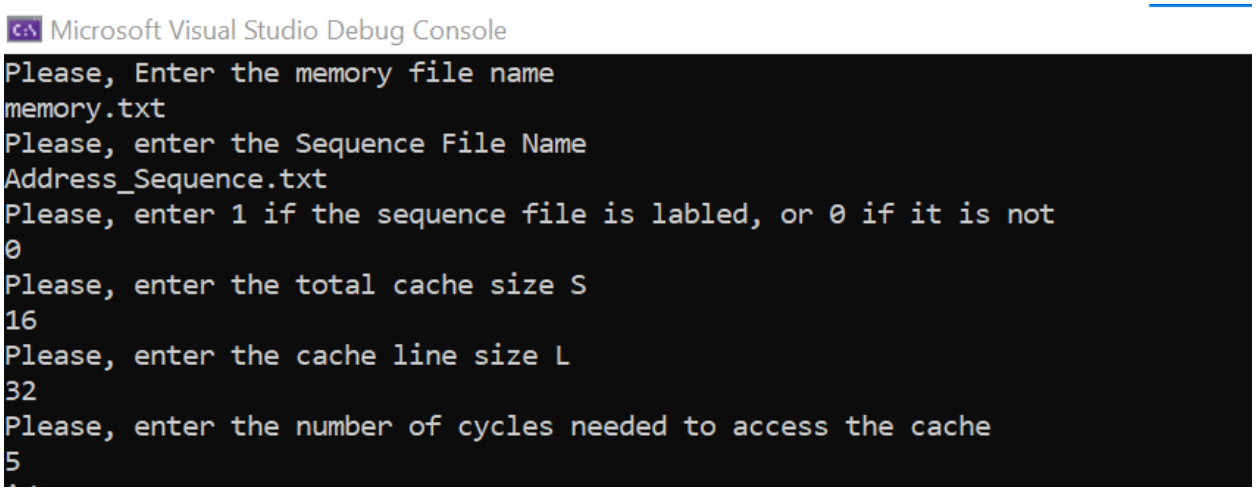
1. The user will first enter the name of the memory text file.
2. He will enter the name of the address sequence text file.

3. He will enter 1 if the sequence file is labeled and 0 if it is not.
4. He will enter the total cache size.
5. He will enter the cache line size.
6. He will enter the number of cycles needed to access the cache.



Example with screenshots

The following screenshots show the output of the following inputs



The Sequence List used in this example:

1011011

1101011

1011000

1101010

1000011

0001101

1000000

1001000

1000111

0000100

0101000

1011011

1101011

0001101

1000000

1001000

The output:

```
idx: 1011011 16
This is a miss

Index   Valid   Tag                             Content
0000    0       00000000000000000000000         00000
0001    0       00000000000000000000000         00000
0010    0       00000000000000000000000         00000
0011    0       00000000000000000000000         00000
0100    0       00000000000000000000000         00000
0101    0       00000000000000000000000         00000
0110    0       00000000000000000000000         00000
0111    0       00000000000000000000000         00000
1000    0       00000000000000000000000         00000
1001    0       00000000000000000000000         00000
1010    0       00000000000000000000000         00000
1011    1       00000000000000000000101         00017
1100    0       00000000000000000000000         00000
1101    0       00000000000000000000000         00000
1110    0       00000000000000000000000         00000
1111    0       00000000000000000000000         00000
Total number of accesses: 1
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------------
```

```
idx: 1101011 16
This is a miss

Index   Valid   Tag                             Content
0000    0       00000000000000000000            00000
0001    0       00000000000000000000            00000
0010    0       00000000000000000000            00000
0011    0       00000000000000000000            00000
0100    0       00000000000000000000            00000
0101    0       00000000000000000000            00000
0110    0       00000000000000000000            00000
0111    0       00000000000000000000            00000
1000    0       00000000000000000000            00000
1001    0       00000000000000000000            00000
1010    0       00000000000000000000            00000
1011    1       00000000000000000110            00018
1100    0       00000000000000000000            00000
1101    0       00000000000000000000            00000
1110    0       00000000000000000000            00000
1111    0       00000000000000000000            00000
Total number of accesses: 2
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------------
```

```
idx: 1101010 16
This is a miss

Index   Valid   Tag                             Content
0000    0       00000000000000000000            00000
0001    0       00000000000000000000            00000
0010    0       00000000000000000000            00000
0011    0       00000000000000000000            00000
0100    0       00000000000000000000            00000
0101    0       00000000000000000000            00000
0110    0       00000000000000000000            00000
0111    0       00000000000000000000            00000
1000    1       00000000000000000101            00019
1001    0       00000000000000000000            00000
1010    1       00000000000000000110            00020
1011    1       00000000000000000110            00018
1100    0       00000000000000000000            00000
1101    0       00000000000000000000            00000
1110    0       00000000000000000000            00000
1111    0       00000000000000000000            00000
Total number of accesses: 4
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 1101010 16
This is a miss

Index   Valid   Tag                                 Content
0000    0       00000000000000000000000000          00000
0001    0       00000000000000000000000000          00000
0010    0       00000000000000000000000000          00000
0011    0       00000000000000000000000000          00000
0100    0       00000000000000000000000000          00000
0101    0       00000000000000000000000000          00000
0110    0       00000000000000000000000000          00000
0111    0       00000000000000000000000000          00000
1000    1       00000000000000000000000101          00019
1001    0       00000000000000000000000000          00000
1010    1       00000000000000000000000110          00020
1011    1       00000000000000000000000110          00018
1100    0       00000000000000000000000000          00000
1101    0       00000000000000000000000000          00000
1110    0       00000000000000000000000000          00000
1111    0       00000000000000000000000000          00000
Total number of accesses: 4
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 1000011 16
This is a miss

Index   Valid   Tag                                 Content
0000    0       00000000000000000000000000          00000
0001    0       00000000000000000000000000          00000
0010    0       00000000000000000000000000          00000
0011    1       00000000000000000000000100          00021
0100    0       00000000000000000000000000          00000
0101    0       00000000000000000000000000          00000
0110    0       00000000000000000000000000          00000
0111    0       00000000000000000000000000          00000
1000    1       00000000000000000000000101          00019
1001    0       00000000000000000000000000          00000
1010    1       00000000000000000000000110          00020
1011    1       00000000000000000000000110          00018
1100    0       00000000000000000000000000          00000
1101    0       00000000000000000000000000          00000
1110    0       00000000000000000000000000          00000
1111    0       00000000000000000000000000          00000
Total number of accesses: 5
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 1101 16
This is a miss

Index   Valid   Tag                             Content
0000    0       00000000000000000000            00000
0001    0       00000000000000000000            00000
0010    0       00000000000000000000            00000
0011    1       00000000000000000100            00021
0100    0       00000000000000000000            00000
0101    0       00000000000000000000            00000
0110    0       00000000000000000000            00000
0111    0       00000000000000000000            00000
1000    1       00000000000000000101            00019
1001    0       00000000000000000000            00000
1010    1       00000000000000000110            00020
1011    1       00000000000000000110            00018
1100    0       00000000000000000000            00000
1101    1       00000000000000000000            00022
1110    0       00000000000000000000            00000
1111    0       00000000000000000000            00000
Total number of accesses: 6
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 1000000 16
This is a miss

Index   Valid   Tag                             Content
0000    1       00000000000000000100            00023
0001    0       00000000000000000000            00000
0010    0       00000000000000000000            00000
0011    1       00000000000000000100            00021
0100    0       00000000000000000000            00000
0101    0       00000000000000000000            00000
0110    0       00000000000000000000            00000
0111    0       00000000000000000000            00000
1000    1       00000000000000000101            00019
1001    0       00000000000000000000            00000
1010    1       00000000000000000110            00020
1011    1       00000000000000000110            00018
1100    0       00000000000000000000            00000
1101    1       00000000000000000000            00022
1110    0       00000000000000000000            00000
1111    0       00000000000000000000            00000
Total number of accesses: 7
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 1001000 16
This is a miss

Index   Valid   Tag                             Content
0000    1       00000000000000000000100         00023
0001    0       00000000000000000000000         00000
0010    0       00000000000000000000000         00000
0011    1       00000000000000000000100         00021
0100    0       00000000000000000000000         00000
0101    0       00000000000000000000000         00000
0110    0       00000000000000000000000         00000
0111    0       00000000000000000000000         00000
1000    1       00000000000000000000100         00024
1001    0       00000000000000000000000         00000
1010    1       00000000000000000000110         00020
1011    1       00000000000000000000110         00018
1100    0       00000000000000000000000         00000
1101    1       00000000000000000000000         00022
1110    0       00000000000000000000000         00000
1111    0       00000000000000000000000         00000
Total number of accesses: 8
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 1000111 16
This is a miss

Index   Valid   Tag                             Content
0000    1       00000000000000000000100         00023
0001    0       00000000000000000000000         00000
0010    0       00000000000000000000000         00000
0011    1       00000000000000000000100         00021
0100    0       00000000000000000000000         00000
0101    0       00000000000000000000000         00000
0110    0       00000000000000000000000         00000
0111    1       00000000000000000000100         00025
1000    1       00000000000000000000100         00024
1001    0       00000000000000000000000         00000
1010    1       00000000000000000000110         00020
1011    1       00000000000000000000110         00018
1100    0       00000000000000000000000         00000
1101    1       00000000000000000000000         00022
1110    0       00000000000000000000000         00000
1111    0       00000000000000000000000         00000
Total number of accesses: 9
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 100 16
This is a miss

Index   Valid   Tag                             Content
0000    1       00000000000000000000100         00023
0001    0       00000000000000000000000         00000
0010    0       00000000000000000000000         00000
0011    1       00000000000000000000100         00021
0100    1       00000000000000000000000         00026
0101    0       00000000000000000000000         00000
0110    0       00000000000000000000000         00000
0111    1       00000000000000000000100         00025
1000    1       00000000000000000000100         00024
1001    0       00000000000000000000000         00000
1010    1       00000000000000000000110         00020
1011    1       00000000000000000000110         00018
1100    0       00000000000000000000000         00000
1101    1       00000000000000000000000         00022
1110    0       00000000000000000000000         00000
1111    0       00000000000000000000000         00000
Total number of accesses: 10
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 101000 16
This is a miss

Index   Valid   Tag                             Content
0000    1       00000000000000000000100         00023
0001    0       00000000000000000000000         00000
0010    0       00000000000000000000000         00000
0011    1       00000000000000000000100         00021
0100    1       00000000000000000000000         00026
0101    0       00000000000000000000000         00000
0110    0       00000000000000000000000         00000
0111    1       00000000000000000000100         00025
1000    1       00000000000000000000010         00027
1001    0       00000000000000000000000         00000
1010    1       00000000000000000000110         00020
1011    1       00000000000000000000110         00018
1100    0       00000000000000000000000         00000
1101    1       00000000000000000000000         00022
1110    0       00000000000000000000000         00000
1111    0       00000000000000000000000         00000
Total number of accesses: 11
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------
```

```
------------------------------------------------------------------------
idx: 1011011 16
This is a miss

Index   Valid   Tag                             Content
0000    1       00000000000000000000100         00023
0001    0       00000000000000000000000         00000
0010    0       00000000000000000000000         00000
0011    1       00000000000000000000100         00021
0100    1       00000000000000000000000         00026
0101    0       00000000000000000000000         00000
0110    0       00000000000000000000000         00000
0111    1       00000000000000000000100         00025
1000    1       00000000000000000000010         00027
1001    0       00000000000000000000000         00000
1010    1       00000000000000000000110         00020
1011    1       00000000000000000000101         00017
1100    0       00000000000000000000000         00000
1101    1       00000000000000000000000         00022
1110    0       00000000000000000000000         00000
1111    0       00000000000000000000000         00000
Total number of accesses: 12
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 1101011 16
This is a miss

Index   Valid   Tag                             Content
0000    1       00000000000000000100            00023
0001    0       00000000000000000000            00000
0010    0       00000000000000000000            00000
0011    1       00000000000000000100            00021
0100    1       00000000000000000000            00026
0101    0       00000000000000000000            00000
0110    0       00000000000000000000            00000
0111    1       00000000000000000100            00025
1000    1       00000000000000000010            00027
1001    0       00000000000000000000            00000
1010    1       00000000000000000110            00020
1011    1       00000000000000000110            00018
1100    0       00000000000000000000            00000
1101    1       00000000000000000000            00022
1110    0       00000000000000000000            00000
1111    0       00000000000000000000            00000
Total number of accesses: 13
Miss ratio= 1
Hit ratio= 0
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 105
--------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 1101 16
This is a hit

Index   Valid   Tag                             Content
0000    1       00000000000000000100            00023
0001    0       00000000000000000000            00000
0010    0       00000000000000000000            00000
0011    1       00000000000000000100            00021
0100    1       00000000000000000000            00026
0101    0       00000000000000000000            00000
0110    0       00000000000000000000            00000
0111    1       00000000000000000100            00025
1000    1       00000000000000000010            00027
1001    0       00000000000000000000            00000
1010    1       00000000000000000110            00020
1011    1       00000000000000000110            00018
1100    0       00000000000000000000            00000
1101    1       00000000000000000000            00022
1110    0       00000000000000000000            00000
1111    0       00000000000000000000            00000
Total number of accesses: 14
Miss ratio= 0.928571
Hit ratio= 0.0714286
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 97.8571
--------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 1000000 16
This is a hit

Index   Valid   Tag                             Content
0000    1       00000000000000000000100         00023
0001    0       00000000000000000000000         00000
0010    0       00000000000000000000000         00000
0011    1       00000000000000000000100         00021
0100    1       00000000000000000000000         00026
0101    0       00000000000000000000000         00000
0110    0       00000000000000000000000         00000
0111    1       00000000000000000000100         00025
1000    1       00000000000000000000010         00027
1001    0       00000000000000000000000         00000
1010    1       00000000000000000000110         00020
1011    1       00000000000000000000110         00018
1100    0       00000000000000000000000         00000
1101    1       00000000000000000000000         00022
1110    0       00000000000000000000000         00000
1111    0       00000000000000000000000         00000
Total number of accesses: 15
Miss ratio= 0.866667
Hit ratio= 0.133333
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 91.6667
--------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
idx: 1001000 16
This is a miss

Index   Valid   Tag                             Content
0000    1       00000000000000000000100         00023
0001    0       00000000000000000000000         00000
0010    0       00000000000000000000000         00000
0011    1       00000000000000000000100         00021
0100    1       00000000000000000000000         00026
0101    0       00000000000000000000000         00000
0110    0       00000000000000000000000         00000
0111    1       00000000000000000000100         00025
1000    1       00000000000000000000100         00024
1001    0       00000000000000000000000         00000
1010    1       00000000000000000000110         00020
1011    1       00000000000000000000110         00018
1100    0       00000000000000000000000         00000
1101    1       00000000000000000000000         00022
1110    0       00000000000000000000000         00000
1111    0       00000000000000000000000         00000
Total number of accesses: 16
Miss ratio= 0.875
Hit ratio= 0.125
The Average Memory Access Time(AMAT) of the memory hierarchy(in cycles)= 92.5
--------------------------------------------------------------------------
```